AF 1773

FEE & TRANSMITTAL FORM

Application No.	09/787,501	Examiner Name	Kruer, Kevin R.
Filing Date	03/16/2001	Group Art Unit	1773
First Named Inventor	Rodway	Attorney Docket No.	RK 590 US

This Transmittal Sheet is accompanied by a Reply to the Office Action mailed May 17, 2005, a marked-up Substitute Specification, a clean Substitute Specification, and an Acknowledgment Postcard

Fee Calculations (Applicant is a small entity ☐ yes ☒ no)

It is believed that no fee is due

Claims after latest amendment

	No. in Specification or after Amendment	No. Included in Filing Fee or Previously Paid For	No. Extra (b)	Applicable Fee	Fee Paid
Total Claims	36	-36 =			
Independent Claims	6	- 6 =			
Multiple dependent claim(s) presented for first time (c)					
				Subtotal (2) Extra claim fees	($)

(3) Additional fees

	Fee Paid

Total Fees

Total Fees Submitted (Sum of Subtotals (1), (2), and (3))

Authorization to Charge Deposit Account for Additional Fees The Commissioner for Patents is hereby authorized to charge any additional fees required under 37 CFR 1.16 and 1.17, and credit any overpayments to, Deposit Account Number 19-2090 (Account Name Sheldon & Mak)

CERTIFICATE OF MAILING UNDER 37 CFR 1.8

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On July 18, 2005 Typed name of person signing this certificate: T. H. P. Richardson

Signature

T.H.P. Richardson

Respectfully Submitted,

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RK590US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: 09/787,501 TC/A.U.: 1773

Applicant: Rodway Examiner: Kruer, Kevin R.

Filing Date: 03/16/2001

Title: Electrical Wire Insulation

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY

Sir,

This paper is a reply to the Office Action mailed May 17, 2005, which is a final rejection. Reexamination, reconsideration and allowance are respectfully requested in view of the Amendments and Remarks below, and the substitute specification and clean version of the substitute specification attached hereto.

A Statement of the Substance of the Interview begins on page 3 of this paper.

A Request to Withdraw the Finality of the Office Action begins on page 4 of this paper.

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On July 18, 2005 Typed name of person signing this certificate: T. H. P. Richardson
Signature

A Request to Enter the Requested Amendments, even if the finality of the office action is maintained, begins on page 7 of this paper.

Amendments to the Specification are set out in the attached Substitute Specification, as noted on page 11 of this paper

Amendments to the Claims are reflected in the listing of claims which begins on page 12 of this paper.

Remarks/Arguments begin on page 24 of this paper.

Page and Line References to the PCT specification in this Reply.

Except where otherwise noted, the references in this Reply to the PCT specification are to the text filed at the PTO when filing the application under 35 USC 371, which is believed to be the same as the text originally filed with the PCT application itself. However, there are minor differences between the PCT specification filed with the application under 35 USC 371 and the published PCT specification. These differences relate only to the precise positioning of the words on the pages, not to the words themselves. It seems possible that the Examiner is working from the published PCT specification. Therefore, where there is a difference between the PCT specification filed with the application under 35 USC 371 and the published PCT specification. ("pub PCT"), the page and line reference in the published PCT specification is also given in parentheses. Neither the PCT specification filed with the application under 35 USC 371 nor the published PCT specification contains line numbers. The line numbers given in this Reply are based on a count of all the lines, including the lines which do not contain words; thus, the number of a line at the end of one paragraph, and the number of a line at the end of the next paragraph, differ by a count of 2.

Statement of the Substance of the Interview.

The Examiner is thanked for his attention to this application during the telephonic interview between the Examiner and the undersigned on June 28, 2005.

At the beginning of the interview, the Examiner confirmed that the rejection under 35 USC 112 was correctly stated (Applicant had thought it possible that the final phrase contained a clerical error and that the rejection was not intended to apply to independent claim 71). The Examiner was asked to explain, but did not explain, why independent claims 57 and 62 (which contain the feature of claim 71 giving rise to its rejection) had not been rejected under 35 USC 112.

Subsequent discussion made it clear that many of the objections and rejections arose because the Examiner was construing the term "layer **which is composed of** a first (or second) polymeric composition" (emphasis added) as an open-ended term such that the layer in question could contain ingredients other than the specified polymeric composition. Applicant believes that such a construction is wrong, but asked the Examiner to consider whether at least some of the objections and rejections would be overcome if the quoted term was amended to "layer **which consists of** a first (or second) polymeric composition" (emphasis added), and also to consider whether such an amendment would be admissible despite the fact that the application is under final rejection. In a subsequent telephone message, the Examiner indicated that

> although he was not making any commitment, he "could not think of a reason why" the amendment would not overcome the 112 rejections,

and that

> he "had reservations" about the admissibility of the amendment because the rejections were not newly applied, the rejection was made clear that in the previous non-final Office Action, and there was nothing clearly of record to show that the term "composed of" should be given the narrow meaning of the "consisting of".

Request to Withdraw the Finality of the Office Action

It is submitted that the finality of the Office Action should be removed for the following reasons.

1. The rejection of independent claim 71 under 35 USC 112 is a new rejection.

2. It is not clear whether claims 57 and 62 (and claims 58-61 dependent on claim 57 and claims 63-67 dependent on claim 62) have been rejected under 35 USC 112; if they have been rejected under 35 USC 112, such a rejection is a new rejection.

These reasons are discussed in turn below.

1. The Rejection of claim 71 under 35 USC 112 is a new rejection.

Claim 71 was rejected in the previous Office Action (mailed November 2, 2004) on the ground that.

There is no support in the original disclosure for a carbonyl-containing polymer that does not have a non-aromatic backbone.

There was no other rejection of claim 71 under 35 USC 112. In the Reply to the previous Office Action, claim 71 was amended to specify that the carbonyl-containing polymer has a non-aromatic backbone, thus overcoming the rejection under 35 USC 112. Claim 71 was not otherwise amended.

The Final Rejection rejects claim 71 under 35 USC 112 on the ground that

There is no support in the original disclosure for embodiments wherein the weight percentages are based on the weight of the first polymeric component or the "first polymeric composition".

This is a new rejection.

2. It is not clear whether claims 57 and 62 (and claims 58-61 dependent on claim 57 and claims 63-67 dependent on claim 62) have been rejected under 35 USC 112; if they have been rejected under 35 USC 112, such a rejection is a new rejection.

Three of the independent claims in this application (claims 57, 62 and 71) require that the weight percentage (of the carbonyl-containing polymer in the first composition) is based on the weight of the composition (i.e. the combined weight of the polymeric component and any other component). Claim 71 was rejected under 35 USC 112. Claims 57 and 62 were not rejected under 35 USC 112.

Paragraph 2 of the Office Action provides the following basis for the rejection of independent claims 28, 37, 51, 68 and 71 (and the claims dependent thereon).

> *There is no support in the original disclosure for embodiments wherein the weight percentages are based upon the weight of the first polymeric component or the "first polymeric composition."*

In the telephone interview on June 28, 2005, the Examiner confirmed that the rejection under 35 USC 112 was correctly stated (Applicant had thought it possible that the final phrase contained a clerical error and that the rejection was not intended to apply to claim 71). The Examiner did not explain why claims 57 and 62 (and claims dependent thereon) had not been rejected under 35 USC 112.

Since the weight percentages in claims 57 and 62 are, like those in claim 71, based on the weight of the first polymeric composition, it is unclear why claims 57 and 62 have not been rejected on the same ground as claim 71.

Like claim 71, claim 57 was rejected in the previous Office Action (mailed November 2, 2004) on the ground that.

> *There is no support in the original disclosure for a carbonyl-containing polymer that does not have a non-aromatic backbone.*

There was no other rejection of claim 57 under 35 USC 112. In the Reply to the previous Office Action, claim 57 was amended to specify that the carbonyl-containing polymer has a non-

aromatic backbone, thus overcoming the rejection under 35 USC 112. Claim 57 was not otherwise amended.

Claim 62 was not rejected under 35 USC 112 in the previous office action.

If indeed claims 57 and 62 are to be rejected under 35 USC 112 on that ground, the rejection will be a new rejection.

It is believed to be clear, from the facts stated above, that a clear issue has not been developed between the Examiner and the Applicant as to whether there is, or is not, a rejection of claims 57 and 62 under 35 USC 112.

Request to Enter the Requested Amendments.

It is submitted that, even if the finality of the office action is maintained, the requested amendments should be entered, since they overcome at least some of the objections and rejections, do not raise any new issues, and place the application in better condition for any appeal that may be necessary.

The amendments to the claims, which will be apparent from the listing of the claims below, can be summarized as follows.

1. Throughout the claims, the term "component" has been replaced by the term --portion--. Page 2 of the Office Action states, in connection with the objection to paragraphs 00006-00007,

> *Applicant points to page 2 of the PCT disclosure for support. However, claim 2 supports the phrase "weight of the polymeric portion," not "weight of the first polymeric component."*

It is apparent, from this statement, that the Examiner perceives a significant difference between the term "portion" and the term "component". Applicant does not think that there is any such difference. However, in the interests of speedy prosecution, the term "component" has been replaced by the term "portion".

2. Each of the independent claims 28, 37, 47, 51 and 68 (i.e. the independent claims in which the percentage of the carbonyl-containing polymer is based on the weight of the polymeric portion of the composition) has been amended to make it clear that the first and second layers **consist of** the first and second polymeric compositions respectively.

3. Each of the independent claims 57, 62 and 71 (i.e. the independent claims in which the percentage of the carbonyl-containing polymer is based on the weight of the entire polymeric composition) has likewise been amended to make it clear that the first and second layers **consist of** the first and second polymeric compositions respectively. In addition, claims 57, 62 and 71 have been amended, so that their wording is consistent

with the wording of claims 28, 37, 47, 51 and 68, to state that the first polymeric composition consists of a first polymeric portion and optionally a first additive portion; and that the second polymeric composition consists of a second polymeric portion and optionally a second additive portion.

The Substitute Specification has been amended in the same way as the claims. The Substitute Specification has also been amended to overcome the objection that the time during which the wire is immersed in acetone had been omitted.

It will be apparent that these amendments have been made in direct response to the objections and rejections made by the Examiner; that the amendments will overcome at least some of the objections and rejections; and that to the extent that the amendments to not overcome all the objections and rejections, they place the application in better condition for appeal.

In his telephone message after the telephonic interview, the Examiner indicated that his reservations about entering the amendments stating that the first and second layers consist of the first and second polymeric compositions respectively, were based upon his understanding that

(a) the rejections were not newly applied,

(b) the rejections were made clear in the previous Office Action, and

(c) there was nothing clearly of record to show that the term "composed of" should be given the narrow meaning of "consisting of".

With regard to (a), the Examiner is asked to refer to the reasons given above for withdrawing the finality of the Office Action.

With regard to (b) and (c), Applicant respectfully disagrees with the Examiner, having regard to the following facts.

A. New claims were filed in the Reply mailed August 18, 2003. Although those claims are not identical with those considered by the Examiner in the outstanding Final

Rejection, they (and the claims in the RCE) **are identical insofar as they relate to the meaning of "composed of".** Thus, the claims refer to the first and second layers as being "composed of" the first and second compositions respectively.

B. The comments on the amended claims on page 20 of the Reply mailed August 18, 2003, state:

> *The new claims set out above require*
>
> *(1) that the first layer of insulation contains at least 60% by weight, based on the weight of the polymers in the composition, of carbonyl-containing polymer;*
>
> *(2) that the second layer contains at least 50% by weight of PVDF or a PDF copolymer or both; and...*

C. The argument against the rejections under 35 USC 103 notes that Miyaki's compositions must contain less than 50% of the carbonyl-containing polymer.

D. The next Official Action (mailed October 20, 2003) withdraws all the rejections under 35 USC 103.

E. MPEP 2111.03 states

> The transitional phrase "composed of" has been interpreted in the same manner as either "consisting of" or "consisting essentially of", depending on the facts of the particular case. See AFP industries Inc. v.Cardinal IG Co., 57 USPQ2d 1776, 1780-81 (Federal Circuit 2001) (based on specification and other evidence, "composed of" interpreted in same manner as "consisting essentially of"); In re Bertsch, 56 USPQ 379, 384 (CCPA 1942) ("composed of" interpreted in same manner as "consisting of"; however, court further remarked that "the words 'composed of' may under certain circumstances be given, in patent law, a broader meaning than 'consisting of'").

It is submitted that these facts make it clear that

(1) Applicant intended at all times that the term "composed of" should be construed to mean "consisting of", there being no other meaning which would be consistent with the statements of record that

> *(1) the first layer of insulation contains at least 60% by weight, based on the weight of the polymers in the composition, of carbonyl-containing polymer;*

(2) that the second layer contains at least 50% by weight of PVDF or a PDF;

and the MPEP; and

(2) the Examiner, when issuing the Office Action of October 20, 2003, understood that the term "composed of" should be construed to mean "consisting of", since he would have maintained the rejections under 35 USC 103 if he had construed the term "composed of" to mean "comprising".

The Office Action mailed November 2, 2004, renews the rejections under 35 USC 103, but contains no explanation why the arguments previously put forward (and accepted) were no longer regarded as persuasive. Paragraph 14 of the Office Action begins by reciting the ingredients of Miyaki's composition, in a way which clearly excludes them from the compositions defined by Applicant's claims. It also includes the statement that

Said composition is understood to read on the "first layer" wherein the component (b) is the first polymeric composition" and the "first polymeric component".

and in retrospect that statement may perhaps be regarded as a clue to the Examiner's changed position. It is submitted, however, that, having regard to the facts set out in paragraphs (A)-(E) above, Applicant should not be penalized for failure to recognize that the Examiner was no longer giving effect to the clear statements of record noted in paragraph (B) above, and was adopting a construction of the term "composed of" different from that which the Applicant had previously made clear and which the Examiner had previously adopted.

Amendments to the Specification:

As required by the Examiner, Applicant files herewith a Substitute Specification, and requests that the specification be amended in accordance with the Substitute Specification. As required by 37 CFR 1.125, the attached substitute specification is submitted with markings showing all the changes relative to immediate prior version of the specification of record, with the added text being underlined and the deletions being shown by strike-through. A clean version of the Substitute Specification is also attached. The undersigned states that the Substitute Specification includes no new matter.

The "immediate prior version of the specification of record" is the original specification as amended by the amendments requested in the Preliminary Amendment and the Reply mailed August 18, 2003, which amendments were entered (see the Office Action mailed October 20, 2003). Further amendments were requested in the Reply mailed February 20, 2004, but were not entered, at the request of the Applicant as part of the Request for Continued Examination. Further amendments were requested in the Submission under 37 CFR 1.114, but were not entered (see paragraph 2 of the Office Action mailed November 2, 2004). Further amendments were requested in the Reply mailed February 2, 2005, but were not entered (see paragraph 1 of the Office Action mailed May 17, 2005).

The attached Substitute Specification is the same as that submitted with the Reply mailed February 2, 2005, except for the changes noted on page 7 above (in the section entitled Request to Enter the Requested Amendments). Since the previously-filed Substitute Specification was not entered, these changes do not appear as such on the marked-up copy, which is of course based on the "the immediate prior version of the specification of record", i.e. the original specification as amended by the amendments requested in the Preliminary Amendment and the Reply mailed August 18, 2003. If it would be helpful to the Examiner, Applicant will be pleased to supply a copy of the previously-filed Substitute Specification marked up to show the changes incorporated into the attached Substitute Specification.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1-27. (Canceled)

28. (Currently amended) An insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion ~~component~~ and optionally a first additive portion ~~component~~, the first polymeric portion ~~component~~ comprising at least 60% by weight, based on the weight of the first polymeric portion ~~component~~, of a carbonyl-containing polymer having a non-aromatic backbone and comprising at least 5% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from a monomer which can be copolymerized with an olefinic monomer and which contains a carboxylic acid ester group, and

(ii) a second layer which is in direct contact with the first layer at an interface, and which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion ~~component~~ and optionally a second additive portion ~~component~~, the second polymeric portion ~~component~~ comprising at least 50% by weight, based on the weight of the second polymeric composition, of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a fluorinated comonomer;

the first layer being positioned between the conductor and the second layer.

29. (Previously presented) An insulated wire according to claim 28 wherein polymers at the interface between the first and second layers are crosslinked.

30. (Previously presented) An insulated wire according to Claim 29 wherein the crosslinking of polymers at the interface is such that at least one of the following conditions is fulfilled:

(a) the peel bond strength between the layers, measured by ASTM 81876- 95, is at least 5N,

(b) when a sample of the insulated electrical wire 60 mm long is immersed to a depth of 42 mm in a bath of acetone at 23 °C for 1 hour, there is no delamination of the two layers, and

(c) the peel bond strength between the layers after the crosslinking, measured by ASTM B1876-95, is at least 100% greater than the peel bond strength between the layers before the crosslinking, measured by ASTM B1876-95.

31. (Currently amended) An insulated wire according to claim 28 wherein the first polymeric portion ~~component~~ consists essentially of the carbonyl-containing polymer and polyethylene.

32. (Currently amended) An insulated wire according to claim 28 wherein the first polymeric portion ~~component~~ consists essentially of the carbonyl-containing polymer and high density polyethylene.

33. (Previously presented) An insulated wire according to claim 28 wherein the second polymeric composition comprises at least 50% by weight, based on the weight of the second polymeric composition, of the VDF copolymer, and the VDF copolymer contains 8 to 12% by weight, based on the weight of the copolymer, of units derived from hexafluoropropylene.

34-36. (Canceled)

37. (Currently amended) An insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion ~~component~~ and optionally a first additive portion ~~component~~, the first polymeric portion ~~component~~ consisting essentially of 60 to 100% by weight, based on the weight of the first polymeric portion ~~component~~, of a carbonyl-containing polymer, and 0 to 40% by weight, based on the weight of the first polymeric portion ~~component~~, of polyethylene, the carbonyl-containing polymer having a non-aromatic backbone and consisting essentially of

(a) 9 to 100% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from a monomer which can be copolymerized with an olefin and which contains a carboxylic acid ester group, and

(b) 91 to 0% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from an olefin; and

(ii) a second layer which is in direct contact with the first layer at an interface, and which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion ~~component~~ and optionally a second additive portion ~~component~~, the second polymeric portion ~~component~~ comprising 90 to 100% by weight, based on the weight of the second polymeric composition, of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a fluorinated comonomer;

the first layer being positioned between the conductor and the second layer.

38. (Previously presented) An insulated wire according to Claim 37 wherein polymers at the interface between the first and second layers are cross-linked.

39. (Previously presented) An insulated wire according to Claim 38 wherein the crosslinking of polymers at the interface is such that, when a sample of the insulated electrical wire 60 mm long is immersed to a depth of 42 mm in a bath of acetone at 23 °C for 1 hour, there is no delamination of the two layers.

40. (Currently amended) An insulated wire according to Claim 37 wherein the first polymeric portion ~~component~~ comprises at least 80% by weight, based on the weight of the first polymeric portion ~~component~~, of the carbonyl-containing polymer.

41. (Canceled)

42. (Previously presented) An insulated wire according to Claim 37 wherein the carbonyl-containing polymer contains 15 to 28% by weight, based on the weight of the carbonyl-containing polymer, of the repeating units containing a carboxylic acid ester group.

43. (Previously presented) An insulated wire according to Claim 37 wherein the repeating units containing a carboxylic acid ester group comprise units derived from vinyl acetate or an alkyl acrylate.

44-45. (Canceled)

46. (Currently amended) An insulated wire according to Claim 37 wherein the first polymeric portion ~~component~~ consists essentially of high-density polyethylene and at least 80% of the carbonyl-containing polymer.

47. (Currently amended) An insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which surrounds and directly contacts the metallic conductor, and which consists ~~is composed~~ of a first polymeric composition consisting of a first

polymeric portion ~~component~~ and optionally a first additive portion ~~component~~, the first polymeric portion ~~component~~ consisting essentially of 60 to 100% by weight, based on the weight of the first polymeric portion ~~component~~, of a carbonyl-containing polymer, and 0 to 40% by weight, based on the weight of the first polymeric portion ~~component~~, of polyethylene, the carbonyl-containing polymer having a non-aromatic backbone and consisting essentially of

(a) 15 to 28% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from an alkyl acrylate, and

(b) 85 to 72% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from ethylene; and

(ii) a second layer which surrounds and directly contacts the first layer and which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion ~~component~~ and optionally a second additive portion ~~component~~, the second polymeric portion ~~component~~ comprising 90 to 100% by weight, based on the weight of the second polymeric composition, of a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) 88 to 92% by weight, based on the weight of the VDF copolymer, of repeating units derived from vinylidene fluoride, and

(b) 8 to 12% by weight, based on the weight of the VDF copolymer, of repeating units derived from a fluorinated comonomer.

48. (Previously presented) An insulated wire according to Claim 47 wherein polymers at the interface between the first and second layers are crosslinked.

49. (Previously presented) An insulated wire according to Claim 48 wherein the crosslinking of polymers at the interface is such that, when a sample of the insulated electrical wire 60 mm long is immersed to a depth of 42 mm in a bath of acetone at 23 °C for 1 hour, there is no delamination of the two layers.

50. (Previously presented) An insulated wire according to Claim 47 wherein the alkyl acrylate is one or both of ethyl acrylate and methyl acrylate.

51. (Currently amended) A method of making an insulated wire, the method comprising the steps of

(A) providing a metallic conductor surrounded by

(i) a first layer which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion ~~component~~ and optionally a first additive portion ~~component~~, the first polymeric portion ~~component~~ comprising at least 60% by weight, based on the weight of the first polymeric portion ~~component~~, of a carbonyl-containing polymer having a non-aromatic backbone and containing at least 5% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from a monomer which can be copolymerized with an olefinic comonomer and which contains a carboxylic acid ester group; and

(ii) a second layer which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion ~~component~~ and optionally a second additive portion ~~component~~, the second polymeric portion ~~component~~ comprising at least 50% by weight, based on the weight of second polymeric composition, of a fluoropolymer which is polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a fluorinated comonomer;

the first and second layers being in direct contact with each other at an interface, and the first layer being positioned between the conductor and the second layer; and

(B) exposing the layers while in contact with each other to ionizing radiation which causes cross-linking of polymers at the interface.

52. (Previously presented) A method according to Claim 51 wherein step (A) comprises bringing the respective layers into contact with each other at a temperature above the melting or softening point of polymeric material in at least one of the layers.

53. (Previously presented) A method according to Claim 51 wherein step (A) includes pressure-extruding layer (i) onto the conductor.

54. (Previously presented) A method according to Claim 51 wherein step (A) comprises coextruding the layers (i) and (ii) onto the conductor in a single pass of the conductor from an extrusion process pay-out device to an extrusion process take-up device.

55-56. (Canceled)

57. (Currently amended) An insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion and optionally a first additive portion, the first polymeric portion comprising at least 60% by weight, based on the weight of the first polymeric composition, of a carbonyl-containing polymer having a non-aromatic backbone and comprising at least 5% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from a monomer which can be copolymerized with an olefinic monomer and which contains a carboxylic acid ester group, and

(ii) a second layer which is in direct contact with the first layer at an interface, and which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion and optionally a second additive portion, the second polymeric portion comprising at least 50% by weight, based on the weight of the second polymeric composition, of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a fluorinated comonomer;

the first layer being positioned between the conductor and the second layer.

58. (Previously presented) An insulated wire according to claim 57 wherein polymers at the interface between the first and second layers are crosslinked.

59. (Previously presented) An insulated wire according to claim 58 wherein the crosslinking of polymers at the interface is such that at least one of the following conditions is fulfilled:

(a) the peel bond strength between the layers, measured by ASTM 81876- 95, is at least 5N,

(b) when a sample of the insulated electrical wire 60 mm long is immersed to a depth of 42mm in a bath of acetone at 23 °C for 1 hour, there is no delamination of the two layers, and

(c) the peel bond strength between the layers after the crosslinking, measured by ASTM B1876-95, is at least 100% greater than the peel bond strength between the layers before the crosslinking, measured by ASTM B1876-95.

60. (Currently amended) An insulated wire according to claim 57 wherein the first polymeric composition comprises a first polymeric portion ~~component~~ which consists essentially of the carbonyl-containing polymer and high density polyethylene.

61. (Previously presented) An insulated wire according to claim 57 wherein the second polymeric composition comprises at least 50% by weight, based on the weight of the second polymeric composition, of the VDF copolymer, and the VDF copolymer is a copolymer of VDF and hexafluoropropylene (HFP) which contains 8 to 12 % by weight, based on the weight of the copolymer, of units derived from HFP.

62. (Currently amended) An insulated electrical wire comprising

1) a metallic conductor, and

3) insulation which comprises

(i) a first layer which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion and optionally a first additive portion, the

first polymeric portion comprising 60 to 100% by weight, based on the weight of the first polymeric composition, of a carbonyl-containing polymer, and 0 to 40% by weight, based on the weight of the first polymeric composition, of high-density polyethylene, the carbonyl-containing polymer having a non-aromatic backbone and consisting essentially of

(a) 9 to 100% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from a monomer which can be copolymerized with an olefin and which contains a carboxylic acid ester group, and

(b) 91 to 0% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from an olefin; and

(ii) a second layer which is in direct contact with the first layer at an interface, and which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion and optionally a second additive portion, the second polymeric portion comprising 90 to 100% by weight, based on the weight of the second polymeric composition, of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a fluorinated comonomer;

the first layer being positioned between the conductor and the second layer.

63. (Previously presented) An insulated wire according to Claim 62 wherein polymers at the interface between the first and second layers are crosslinked.

64. (Currently amended) An insulated wire according to Claim 62 wherein the first polymeric composition comprises at least 80% by weight, based on the weight of the first polymeric portion ~~polymers therein~~, of the carbonyl-containing polymer.

65. (Previously presented) An insulated wire according to Claim 62 wherein the carbonyl-containing polymer contains 15 to 28% by weight, based on the weight of the carbonyl-containing polymer, of the repeating units containing a carboxylic acid ester group.

66. (Previously presented) An insulated wire according to Claim 62 wherein the repeating units containing a carboxylic acid ester group comprise units derived from vinyl acetate, ethyl acrylate or methyl acrylate.

67. (Previously presented) An insulated wire according to Claim 62 wherein the polymeric portion of the first polymeric composition consists essentially of high-density polyethylene and the carbonyl-containing polymer.

68. (Currently amended) An insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which surrounds and directly contacts the metallic conductor, and which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion and optionally a first additive portion, the first polymeric portion ~~comprising a polymeric component~~ consisting essentially of 60 to 100% by weight, based on the weight of the first polymeric portion ~~component~~, of a carbonyl-containing polymer, and 0 to 40% by weight, based on the weight of the first polymeric portion ~~component~~, of high-density polyethylene, the carbonyl-containing polymer having a non-aromatic backbone and consisting essentially of

(a) 15 to 28% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from an alkyl acrylate, and

(b) 85 to 72% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from ethylene; and

(ii) a second layer which surrounds and directly contacts the first layer at an interface and which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion and optionally a second additive portion,

the second polymeric portion comprising 90 to 100% by weight, based on the weight of the second polymeric composition, of a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) 88 to 92% by weight, based on the weight of the VDF copolymer, of repeating units derived from vinylidene fluoride, and

(b) 8 to 12% by weight, based on the weight of the VDF copolymer, of repeating units derived from a fluorinated comonomer.

69. (Previously presented) An insulated wire according to Claim 68 wherein polymers at the interface between the first and second layers are crosslinked.

70. (Previously presented) An insulated wire according to Claim 68 wherein the alkyl acrylate is one or both of ethyl acrylate and methyl acrylate.

71. (Currently amended) A method of making an insulated wire, the method comprising the steps of

(A) providing an electrical conductor surrounded by

(i) a first layer which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion and optionally a first additive portion, the first polymeric portion comprising at least 60% by weight, based on the weight of the first polymeric composition, of a carbonyl-containing polymer having a non-aromatic backbone and containing at least 5% by weight, based on the weight of the carbonyl-containing polymer, of repeating units derived from a monomer which can be copolymerized with an olefinic comonomer and which contains a carboxylic acid ester group; and

(ii) a second layer which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion and optionally a second additive portion, the second polymeric portion comprising at least 50% by weight, based on the weight of second polymeric composition, of a fluoropolymer which is polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a fluorinated comonomer;

the first and second layers being in direct contact with each other at an interface, and the first layer being positioned between the conductor and the second layer; and

(B) exposing the layers while in contact with each other to ionizing radiation which causes cross-linking of polymers at the interface.

72-73. (Canceled)

74. (Currently amended) A method according to claim 71 wherein ~~the first polymeric composition consists of a first polymeric component and optionally a first additive component, and~~ the first polymeric portion ~~component~~ consists essentially of the carbonyl-containing polymer and polyethylene.

74. (Currently amended) A method according to claim 51 wherein the first polymeric portion ~~component~~ consists essentially of the carbonyl-containing polymer and polyethylene.

REMARKS/ARGUMENTS

Amendment of the Specification

It appears clear, from the Office Action mailed May 17, 2005, that the Examiner, after consideration of the Reply to the previous Office Action, has withdrawn all of the objections made in the previous Office Action except the objection to paragraphs 00006-00007 set out in the outstanding Office Action and the new objection to paragraph 00014. Therefore, in the interests of brevity, and although the Substitute Specification has not been entered, Applicant is not repeating in this Reply the very detailed explanation of the basis in the PCT specification for the Substitute Specification.

As noted on page 7 above (in the section entitled Request to Enter the Requested Amendments), the specification has been amended by

(1) replacing the term "component" by the term "portion",

(2) replacing the term "is composed of " by the term "consists of",

(3) amending the statement of invention corresponding to independent claims 57, 62 and 71 so that its wording is consistent with the wording of the amended claims, and

(4) amending paragraph 00014 so that it refers to the time during which the wire it is immersed in acetone.

Amendment of the Claims

As noted on page 7 above (in the section entitled Request to Enter the Requested Amendments), the claims have been amended by

(1) replacing the term "component" by the term "portion",

(2) replacing the term "is composed of " by the term "consists of", and

(3) amending independent claims 57, 62 and 71 so that their wording is consistent with the wording of the other independent claims.

In addition, a minor amendment has been made to claim 64 so that its wording is consistent with the other claims.

The Objections to the Specification.

It is submitted that the remaining objections should be withdrawn, and the Substitute Specification entered, having regard to the requested amendments, the reasons set out in the previous Reply, and the following reasons.

1. The objection to paragraph 00006.

The objection to paragraph 00006 is that

There is no support in the original disclosure for embodiments wherein the weight percentages are based upon the weight of the first polymeric component. Applicant points to claim 2 of the PCT specification for support. However, claim 2 supports the phrase "weight of the polymeric portion", not "weight of the first polymeric component".

It appears that the Examiner agrees that there is support for basing the weight of the carbonyl-containing polymer on the weight of the polymeric **portion** of the first polymeric composition, but not for basing the weight of the carbonyl-containing polymer on the weight of polymeric **component** of the first polymeric composition. Applicant is not able to understand the distinction that the Examiner is drawing between the terms "portion" and "component", but in the interests of speedy prosecution has requested amendment of the specification (and claims) to replace the term "component" by the term "portion". It is believed that this amendment will overcome the objection. However, for the sake of completeness, Applicant draws the Examiner's attention to the following passages which provide basis for paragraph 00006.

a. PCT claim 2 refers to

at least a first layer of a polyolefin-based formulation, of which... at least 60%... of the weight of the polymeric portion of the said formulation consists of a carbonyl-containing polymer...

b. PCT page 3 lines 12-14 (pub PCT page 3, lines 13-16) and the Abstract contain substantially the same disclosure as PCT claim 2.

c. PCT page 4, lines 10-13 (pub PCT page 4, lines 12-15) states

the polyolefin-based layer (i) in addition to the polymeric portion of the formulation, for which the requirements are stipulated above, may contain whatever else is required in the way of additives such as...

2. The objection to paragraph 00007

The objection to paragraph 00007 is that

There is also no support for the limitation that the second polymeric component comprises at least 90% by weight "based on the weight of the second polymeric composition". Applicant points to page 2 of the PCT disclosure for support. However, said disclosure fails to disclose what the weight percentages based upon.

Applicant submits that there is support for the limitation in question, as set out below for the two different embodiments of the invention, namely the embodiment in which the amount of the carbonyl-containing polymer is based on the weight of the whole composition, and the embodiment in which the amount of the carbonyl-containing polymer is based on weight of the first polymeric portion.

2(i). The support for this limitation in the context of the embodiments of the invention in which the amount of the carbonyl-containing polymer is based on the weight of the whole composition.

PCT page 2, line 31 - page 3, line 2 (pub PCT page 3, lines 1-4) refers (in a statement of invention in which the amount of the carbonyl-containing polymer in the first layer is based on the weight of the whole composition) to

... a second layer of a material containing at least 10%, more preferably at least 50% or at least 90% by weight of a polyvinylidene fluoride (PVDF), or especially preferably a copolymer based on VDF...

PCT claim 1 refers (in a claim in which the amount of the carbonyl-containing polymer in the first layer is likewise based on the weight of the whole composition) to

... a second layer of a material containing at least 10%, by weight based on th e total material composition, of polyvinylidene fluoride (PVDF) or of a copolymer based on VDF...

Applicant submits that, where, as in the passage quoted above from PCT page 2, line 31 - page 3, line 2 (pub PCT page 3, lines 1-4), a composition is stated to contain a particular percentage by weight of an ingredient, the first and most obvious meaning is that the percentage is based on the whole composition. If there could be any doubt about this, it is removed, in the context of the PCT specification, by the wording of PCT claim 1, quoted above, which states explicitly that the 10% value is by weight based on the total material composition, and thus confirms that not only the 10% value, but also the 50% and 90% values, in the passage on page 3 are by weight based on the total material composition.

2(ii). The support for this limitation in the context of the embodiments of the invention in which the amount of the carbonyl-containing polymer is based on the weight of the polymeric component.

PCT page 3, lines 22-26 (pub PCT page 3, lines 23-27) refers (in a statement of invention in which the amount of the carbonyl-containing polymer in the first layer is based on the weight of the polymeric portion of the first layer) to

... a second layer of another material formulation containing at least 10%, more preferably at least 50%, very preferably at least 90%, especially 100%, by weight of the second layer, or polyvinylidene fluoride (PVDF), or especially preferably...

This passage states explicitly that the percentages are based on weight of the second layer. PCT claim 2 has the same disclosure.

3. The objection to paragraph 00014

In the attached Substitute Specification, paragraph 00014 has been amended to include the time during which the layer is immersed in acetone.

The Rejection under 35 USC 112

Applicant respectfully traverses the rejection of claims 28-33, 37-40, 42-54 (no doubt 42, 43, 46-54 was intended, since claims 44 and 45 have been canceled), 68-70 and 72-73 under 35 USC 112, insofar as that rejection is applicable to the amended claims, for the following reasons.

As noted on page 3 above (in the section entitled Statement of the Substance of the Interview), the Examiner has given a preliminary indication that the amendments replacing "is composed of " by "consists of" will overcome the rejections under 35 USC 112. However, for the sake of completeness, following additional comments are made.

The stated basis for the rejection under 35 USC 112 is

There is no support in the original disclosure for embodiments wherein the weight percentages are based on the weight of the first polymeric component or the "first polymeric composition".

As previously noted, in one embodiment of the invention (the "first aspect of the invention", as claimed for example in independent claims 28, 37, 47, 51 and 68), the percentage of the carbonyl-containing polymer is based on the weight of the first polymeric portion (previously "component"), whereas in another embodiment of the invention (the "second aspect of the invention" as claimed for example in independent claims 57, 62 and 71), the percentage of the carbonyl-containing polymer is based on the weight of the (entire) polymeric composition.

Applicant submits that there is support for the basis for the percentages of the carbonyl-containing polymer, as set out below for the two different embodiments of the invention.

The support for this limitation in the context of the embodiments of the invention ("first aspect") in which the amount of the carbonyl-containing polymer is based on the weight of the polymeric portion (previously "component") of the first polymeric composition.

As discussed in detail on page 25 above (paragraph 1 of the section entitled The Objections to the Specification, in connection with the basis for the "first aspect of the invention" in the specification, it is believed to be clear that there is basis in the PCT specification for claims in which the weight percentages in the first polymeric composition are based upon the weight of the first polymeric portion (previously "component").

The support for this limitation in the context of the embodiments of the invention ("second aspect") in which the amount of the carbonyl-containing polymer is based on the weight of the (entire) first polymeric composition.

PCT page 2, lines 20-23 (pub PCT, page 2, lines 23-25), refers to

at least a first layer of a polyolefin-based material comprising, of which at least 20%, preferably at least 40%, more preferably at least 60% or at least 80%, ***by weight (of the whole material composition)*** *of a carbonyl-containing polymer... (emphasis added)*

PCT claim 1 refers to

at least a first layer of a polyolefin-based material comprising at least 20%, ***by weight (of the whole material composition)*** *of a carbonyl-containing polymer... (emphasis added)*

The Rejections under 35 USC 103

Applicant respectfully traverses the rejection under 35 USC 103 of

(a) claims 28-32, 37-40, 42, 43, 46, 51-54, 57-67, 74 175 as unpatentable over WO 97/27260 (hereinafter "Miyaki") in view of U.S. Patent No. 4,693,940 (hereinafter "Vogdes"), and

(b) claims 33, 47-50, 61 and 68-70 as unpatentable over Miyaki in view of Vogdes and US Patent No. 4,804,702 (hereinafter "Bartoszek")

insofar as those rejections are applicable to the amended claims, for the following reasons.

The starting point for each of these rejections is the Miyaki reference. As discussed in detail below, Miyaki points away from the claimed invention by making it clear that Miyaki, in order to achieve his objectives, must avoid the use of compositions as defined by Applicant's claims.

Miyaki "has the objective of improving the adhesion of fluorinated resins to metal materials, and of offering a method for obtaining composite materials of metal materials and fluorinated resins" (page 1, lines 33-35). This objective is stated to be achieved through the use of an adhesive composition comprising at least two of (a) a polyvinylidene fluoride (PVDF) resin, (b) an acrylic or methacrylic polymer containing functional groups, e.g. ester groups, for example a polymer containing units derived from methyl acrylate or ethyl acrylate, and (c) a vinylidene fluoride (VDF) copolymer, e.g. a copolymer of vinylidene fluoride and hexafluoropropylene. The acrylic/methacrylic polymer (b) is of course a carbonyl-containing polymer. Miyaki's adhesive composition can be used as an intermediate layer between a metal substrate and an outer layer of a fluorinated resin.

The disclosure of Miyaki's adhesive compositions on page 2, lines 2-10, and in claim 1, does not specify the proportions of the polymers (a), (b) and (c). However, the rest of Miyaki makes it clear that the polymers (a), (b) and (c) must be used in specific proportions, and in particular that the amount of the acrylic/methacrylic polymer (b) must not exceed 50% of the total of the polymers (a), (b) and (c). Thus, Miyaki, Page 3, lines 28-31, states

> *When the metal-adhesive composition contains (a), (b) and (c) components, it contains from 0.5 to 100 parts by weight of an acrylic and/or methacrylic polymer (b), from 1 to 200 parts by weight of vinylidene fluoride copolymer resin (c) per 100 parts by weight of polyvinylidene fluoride resin (a).*

and Miyaki page 4, lines 19- 24, states

In particular, in the case where the adhesion process is a melt process, it is preferred that the three component-composition is composed of 5 to 100 parts by weight of the acrylic or methacrylic polymer (b) with bonding properties or affinity in terms of metals and from 10 to 200 parts by weight of vinylidene fluoride copolymer (c) per 100 parts by weight of PVDF resin (a).

and Miyaki page 7, lines 12-20, states

The present invention provides improved binders consisting of the above metal-adhesive compositions:

1/ which contains (a) and (b) only, the amount of (b) corresponding to 0.5 to 20 wt% of the total composition

2/ which contains (a) and (c) only, the amount of (c) corresponding to 0.5 to 50 wt% of the total composition,

3/ which contains (a) (b) and (c) only, the amount of (b) correspond to 0.5 to20 wt% of total composition and the amount of (c) corresponding to 0.5 to 50 wt%...

and the Examples of Miyaki's invention use less than 20% of the acrylic/methacrylic polymer and provide good results, whereas Miyaki's Comparative Example 1, in which the adhesive composition contains 100 parts of a PVDF resin and 30 parts of the acrylic/methacrylic polymer (i.e. about 23% of the acrylic/methacrylic polymer) provides poor results.

The Office Action states that Miyaki's adhesive composition comprise

(a) 100 parts by weight of a PVDF resin,

(b) 5-100 parts by weight of an acrylic and/or methacrylic polymer having functional groups, and

(c) 10-200 parts by weight of a vinylidene fluoride copolymer.

The acrylic and/or methacrylic polymer is a carbonyl-containing polymer as defined by the present claims. Thus, though the summary in the Office Action is less detailed than the summary set out above, it is clear that the Examiner agrees that Miyaki's adhesive compositions comprise less than 50% by weight, based on the weight of the specified polymers (a), and (b) and (c), of the carbonyl-containing polymer.

Nevertheless, the Office Action asserts that

said composition is understood to read on the "first layer" wherein the component (b) is the "first polymeric composition" and the "first polymeric component".

That assertion is apparently based upon the Examiner's construction of the claims as covering layers in which the first layer included polymers in addition to the specified polymeric component (now amended to "polymeric portion"). Even assuming that construction to be correct (which Applicant thinks it is not, for the reasons given above), Applicant does not understand how this assertion could possibly be true when applied to the claims in which the weight percentage of the carbonyl-containing polymer is based upon the weight of the entire first polymeric composition. Nonetheless, in the interests of speedy prosecution, Applicant has replaced the term "is composed of" by the term "consists of", so that it is now clear that the that the first layer cannot include polymers in addition to the specified first polymeric component (now amended to the "polymeric portion"), and likewise that the second layer cannot include polymers in addition to the specified second polymeric portion. This amendment, it is believed, puts it beyond doubt that Miyaki's adhesive composition cannot be Applicant's first polymeric composition, and indeed that Miyaki points away from Applicant's first polymeric composition as defined in all the independent claims (i.e. both in the claims in which the percentage of the carbonyl-containing polymer is based on the weight of the polymeric portion and in the claims in which the percentage of the carbonyl-containing polymer is based on the weight of the (entire) polymeric composition).

Thus, independent claims 28, 37, 47, 51 and 68 (which are directed to the first aspect of the invention) require that the first polymeric component should comprise at least 60%, based on the weight of the first polymeric portion, of the carbonyl-containing polymer. This 60% minimum is substantially greater than the 50% maximum which is the outer limit of Miyaki's disclosure, and far, far above the 20% maximum preferred by Miyaki, and in fact demonstrated by Miyaki's Comparative Example 1 to be a practical maximum.

Similarly, independent claims 57, 62 and 71 (which are directed to the second aspect of the invention) require that the first polymeric composition should contain at least 60%, based on

the weight of the whole composition, of the carbonyl-containing polymer. Thus, if the first polymeric composition also contains other ingredients, the minimum amount of the carbonyl-containing polymer, based on all the polymers present, must be even higher than the 60% minimum in the first aspect of the invention.

Dependent claims 40 and 64 require that the first polymeric composition contains at least 80% of the carbonyl-containing polymer, and are yet further distinguished from Miyaki's adhesive compositions.

Independent claims 47 and 68 and dependent claims 31, 32, 46, 60, 67, 74 and 75 require that the polymeric portion of the first polymeric composition consists essentially of the carbonyl-containing polymer and polyethylene, thus excluding the possibility that the composition should also contain a PVDF resin or vinylidene fluoride copolymer resin, at least one of which must be present in Miyaki's adhesive compositions.

Neither the secondary reference, Vogdes, nor the tertiary reference, Bartoszek, does anything to supplement the deficiencies of Miyaki noted above.

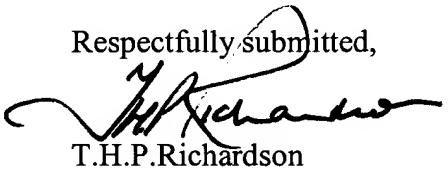
Vogdes is concerned only with the adhesion between two layers of incompatible polymers (one of which may be a VDF polymer), as defined on column 2, lines 25-36, of Vogdes, whereas the two polymeric layers in Miyaki are compatible with each other, and the focus of Miyaki is on obtaining good adhesion between a metal substrate and a VDF polymer. There is no reason, therefore, why one seeking to modify Miyaki's teaching would regard Vogdes as a useful source of information. It is well-settled law that a rejection cannot properly be based on a combination of references unless there is some reason to read the references together.

It is believed to be clear, having regard to the facts and arguments set out above, that the rejections under 35 USC 103 should be withdrawn.

CONCLUSION

It is believed that this application is now in condition for allowance, and Applicant respectfully requests that a timely Notice of Allowance be issued in this case. If, however, there are any outstanding issues that could usefully be discussed by telephone, the Examiner is asked to call the undersigned.

Respectfully submitted,



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[00001] BACKGROUND OF THE INVENTION

[00002] This invention relates to insulation for electrical wire or cable.

[00003] Wire and cable with dual wall insulation comprising a polyolefin inner layer and polyvinylidene fluoride (PVDF) outer layer have been commercially available for over 30 years. In such insulated products, the adhesion between the polyolefin and PVDF layers is negligible, and as a result the products suffer from the certain disadvantages.

[00004] SUMMARY OF THE INVENTION

[00005] It has now been discovered, according to the present invention, that insulation can be provided by a first layer consisting of a first polymeric composition which comprises a carbonyl-containing polymer and which is as defined below, and an adjacent second layer consisting of a second polymeric composition which comprises a fluoropolymer and which is as defined below, these layers being bonded together by cross-linking. The invention makes it possible to achieve high-performance bonding between such layers while retaining an acceptable balance in the complex relationships of other wire performance requirements.

[00006] In a first aspect, this invention provides an insulated electrical wire comprising

1) a metallic conductor, and

2) insulation comprising

(i) a first layer which consists of a first polymeric composition consisting of a first polymeric portion and optionally a first additive portion, the first polymeric portion comprising at least 60%, preferably at least 80%, by weight, based on the weight of the first polymeric portion, of a carbonyl-containing polymer which has a non-aromatic backbone and which may be a homopolymer or copolymer, including terpolymer, the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate,

propyl acrylate or butyl acrylate), the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% , for example 15 to 28%, by weight of the carbonyl-containing polymer and any other repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene;

(II) a second layer which is in direct contact with the first layer at an interface, and which consists of a second polymeric composition consisting of a second polymeric portion and optionally a second additive portion, the second polymeric portion comprising at least 50%, particularly at least 90%, for example 100%, by weight based on the weight of the second composition, of polyvinylidene fluoride (PVDF) or a vinylidene chloride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene chloride, and

(b) repeating units derived from a partially or fully fluorinated co-monomer, preferably hexafluoropropylene (HFP);

the first layer being positioned between the conductor and the second layer.

[00007] In a second aspect, this invention provides an insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which consists of a first polymeric composition consisting of a first polymeric portion and optionally a first additive portion, the first polymeric portion comprising at least 60%, preferably at least 80%, by weight, based on the weight of the first polymeric composition, of a carbonyl-containing polymer which has a non-aromatic backbone and which may be a homopolymer or copolymer, including terpolymer, the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate, propyl acrylate or butyl acrylate), the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% , for example 15 to 28%, by weight of the carbonyl-containing polymer, and any other

repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene, and

(ii) a second layer which is in direct contact with the first layer at an interface, and which consists of a second polymeric composition which consists of a second polymeric portion and optionally a second additive portion, the second polymeric portion comprising at least 50%, preferably at least 90%, for example 100%, by weight, based on the weight of the second polymeric composition, of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a partially or fully fluorinated comonomer, preferably hexafluoropropylene (HFP);

the first layer being positioned between the conductor and the second layer.

[00008] Preferably, in each of the first and second aspects of the invention, the layers (i) and (ii), while in contact with each other, have been subjected to conditions which cause cross-linking of polymers at the interface between them, preferably by subjecting the layers to radiation, particularly ionising radiation. The cross-linking is preferably such that at least one of the following conditions is fulfilled

(a) the peel bond strength between the layers, measured by ASTM 81876- 95, is ~~to~~ at least 5N, preferably more than 10N,

(b) when a sample of the insulated electrical wire 60 mm long is immersed to a depth of 42 mm in a bath of acetone at 23 °C for 1 hour, there is no delamination of the two layers, and

(c) the peel bond strength between the layers after the crosslinking, measured by ASTM B1876-95, is at least 50%, preferably at least 100%, especially at least 500% or 1000%, greater than the peel bond strength between the layers before the crosslinking, measured by ASTM B1876-95.

[00009] A third aspect of the invention provides a method of making an insulated wire or cable, the method comprising the steps of

(A) providing an electrical conductor surrounded by

(i) a first layer which consists of a first polymeric composition as defined in the first or second aspect of the invention; and

(ii) a second layer which consists of a second polymeric composition as defined in the first or second aspect of the invention;

the first and second layers being in direct contact with each other at an interface, and the first layer being positioned between the conductor and the second layer; and

(B) exposing the layers while in contact with each other to ionising radiation which causes cross-linking of polymers at the interface.

[00010] DETAILED DESCRIPTION OF THE INVENTION

[00011] In some embodiments of the invention, the first polymeric portion contains, in addition to the carbonyl-containing polymer, polyethylene, preferably high-density polyethylene.

[00012] Each of the layers (i) and (ii) optionally contains, in addition to the polymeric portion of the composition, an additive portion to give the composition required properties.

[00013] Examples of additives which may be present in the first polymeric composition are cross-linking promoters, antioxidants, pigments, fillers, flame retardants, etc. as known per se. Examples of additives which may be present in the second polymeric composition are cross-linking promoters, pigments, plasticizers, stabilizers, antioxidants and process aids.

[00014] A convenient method for gauging the bond strength between the layers (i) and (ii), when they have been fabricated onto a wire, is to immerse a sample wire, of total length 60mm, in a bath of acetone (e.g. Fisher Scientific UK, AR certified grade acetone) at 23°C for 1 hour, to a depth of 42 mm. Wires with negligible bonding of the insulation layers experience an extension of the outer layer, along the axis of the wire, that is independent of any extension of the inner layer, and/or wrinkling of the outer layer such that it delaminates from the inner layer in places. When it occurs, the above-mentioned extension of the outer layer typically results in a "tube"

extending for 1mm or more beyond the cut end of the inner layer. Wires with significantly bonded insulation layers experience an extension of both layers without separation, beyond the cut edge of the conductor, along the axis of the wire and/or wrinkling of the two layers together, without delamination. Any such wrinkling of the two layers together can be distinguished from wrinkling only of the outer layer by examining a cross-section of the wrinkles under a microscope.

[00015] In the method of the invention, step (A) can make use of any process which causes intimate contact between the layers (i) and (ii). Examples include coating the second polymeric composition onto a pre-formed layer of the first polymeric composition, and dual or multi-walled extrusion to form insulation layers respectively containing one or other of the polymeric compositions. The layers made from the two different compositions can be coextruded, tandem extruded, multipass extruded, or coated by other means. Known wire insulation processes such as tube draw-down extrusion may be used to form one or more of the layers, but pressure extrusion as known per se is preferred for optimum adhesion of the second and any subsequent insulation layers to be applied to a pre-formed underlying layer. The first layer can optionally be in direct contact with the conductor. The insulation can consist of a first layer as defined and a second layer as defined. The insulation can be, for example, multiple alternating layers of the first and second polymeric compositions.

[00016] In step (B) of the method of the invention, the insulation on the wire is exposed to conditions which cause a cross-linking reaction. The cross-linking may involve chemical reagents such as peroxides, but preferably is effected by radiation, especially radiation from a source of ionising radiation capable of causing the formation of free radicals and, thus, cross-links, in the polymers, some of which should preferably be formed in the region of the interface between the two compositions. Penetration of the radiation into the insulation at least as far as the interface is therefore desirable, although not necessarily essential if ion or radical mobility, for example, enables molecular reactions to continue at or near the interface after the radiation process. The radiation source could, for example, be a radio-isotope, or an X-ray source, or possibly a non-ionising radical-generating source, for example a UV source, but is preferably an electron beam, more preferably one providing a beam dose greater than 2 Mrads, preferably at

least 5 Mrads, more preferably at least 10 Mrads, very preferably at least 15Mrads, into the material.

[00017] It has been found that, when the cross-linking is effected by ionizing radiation, enhancements to the interfacial bond strength may be obtained by including a cross-linking promoter ("pro-rad") in the first and/or second polymeric composition. Known pro-rads may be used, preferably methacrylate/acrylate based pro-rads, e.g. imethylolpropanetrimethacrylate (TMPTM).

[00018] Experimental results:

[00019] All results quoted in the tables below were obtained by testing pressed plaques of the two materials prepared by the usual polymer handling techniques, well known per se. The plaques were pressed together to bond them face-to-face and the bonded assembly was irradiated as indicated. Plaques were used for these demonstration experiments rather than wires, due to the relative ease of measuring bond strength on plaques. Conditions for these experiments were as follows:

Plaque dimensions: 150mm by 150mm by 0.85mm
Pressing temperature: 200°C
Pressing time: 2 minute preheat, 1 minute at pressure
Pressing pressure: 20-40 Tons over a 300mm by 300mm metal plate
Cooling conditions: 2 minutes between water cooled, 300mm by 300mm, metal plates, at a pressure as above.

[00020] In the Experimental Results shown below, the first composition (comprising the carbonyl-containing polymer) is referred to as the polyolefin-based material and as Material 1, and the second composition is referred to as the PVDF-based material and as Material 2; and the following abbreviations are used (in addition to those already given). EVA is ethylene/vinyl acetate copolymer. VA is vinyl acetate. EEA is ethylene/ethyl acrylate copolymer. EA is ethyl acrylate. EMA is ethylene/methyl acrylate copolymer. MA is methyl acrylate. HDPE is high-density polyethylene. PVDF is polyvinylidene fluoride.

[00021] Example of Effect of Radiation Dose on Bond strength developed between appropriate polyolefin and PVDF-based materials

Material 1	Material 2	Dose(Mrad)	Peel force (N)
EVA copolymer of 25wt% VA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	0	0.5
Same as above	Same as above	15	40
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	0	1
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	8	24
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	20	52
Ethylene/acrylic ester/maleic anhydride terpolymer of 19wt% acrylic ester content	VDF/HFP copolymer of 10wt% HFP content	0	<5
Ethylene/acrylic ester/maleic anhydride terpolymer of 19wt% acrylic ester content	VDF/HFP copolymer of 10wt% HFP content	20	21

[00022] Example of Effect of Percentage Comonomer in Ethylene Copolymer Material on bond strength to appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
EMA copolymer with 9wt% MA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	4
EMA copolymer with 28wt% MA content	Same as above	20	45

[00023] Example of Effect of percentage Copolymer in a polyolefin polymer blend on bond strength with appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel force (N)
100% HDPE	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	0
20% HDPE + 80% EEA copolymer of 15wt% EA content	Same as above	20	70

[00024] Example of Effect of PVDF-based material type on bond strength with appropriate polyolefin based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
EVA copolymer with 25wt% VA content	PVDF homopolymer	15	4
As above	VDF/HFP copolymer of 10wt% HFP content	15	17.5

[00025] Example of Effect of the addition of Pro-rad in Olefinic Material on bond strength with appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
20% HDPE + 80% EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	70
19% HDPE + 77%EEA copolymer of 15wt% EA content + 4% TMPTM pro-rad	Same as above	20	>130

[00026] Examples of Wire Construction

[00027] An electrical wire in which the insulation consists of two polymeric layers bonded together according to the present invention was made as follows:

[00028] The inner layer of insulation (i.e. nearer to the wire conductor) was a polyolefin-based material, consisting predominantly of (a) an EEA copolymer containing 15wt% EA and (b) HDPE in a weight ratio of approximately 8:2 copolymer:HDPE, with usual other additives present in smaller proportions including crosslinking promoters, stabilisers, antioxidants, pigments and process aids at a total level of 24wt%. This layer was pressure extruded onto the metallic conductor.

[00029] The outer layer of insulation consisted predominantly of a PVDF/HFP copolymer containing 10wt% HFP, which in this example contains a crosslinking promoter, and other known additives such as pigments, plasticisers, stabilisers, antioxidants and process aids in usual proportions totalling 7.5wt%. This outer layer was pressure extruded in a separate operation onto the pre-formed inner layer. This coated wire product was then passed through an electron beam, and received a radiation dose of 20Mrads.

[00030] In a second example a wire was made as above, in which the crosslinking promoter in the inner layer was 4% TMPTM, and the the outer layer of insulation was comprised solely of the PVDF/HFP copolymer containing 10wt% HFP. This coated wire product was then passed through an electron beam, and received a radiation dose of 20 Mrads. This wire was subjected to the acetone immersion test, confirming that the insulation layers were significantly bonded together.

[00031] In a third example, a wire of the same construction as the second example was made by tandem pressure extrusion of the inner and outer insulation layers. This coated wire product was then passed through an electron beam, and received a radiation dose of 20 Mrads. This wire was subjected to the acetone immersion test, confirming that the insulation layers were significantly bonded together.

[00032] Demonstration of Improved performance of wires constructed as in the second example above, relative to current commercially available wire.

[00033] A wire of the above construction and manufacturing process (designated wire A) was compared with a market leading commercially available polyolefin/PVDF dual-walled wire (designated wire B) of the same dimensions, over a range of tests for wire robustness relevant to harsh handling and end-use environments. The following results were obtained.

[00034] Example of scrape abrasion resistance improvement.

[00035] Method: Equipment=conventional type wire scrape abrader, wire size 0.75mm^2(conductor cross sectional area), blade type flat, width 3.5mm held perpendicular to wire, with 0.05mm radiused edges each side, applied load 1.8kg, stroke length 10cm, at 55 cycles/minute

Wire Type	No. of scrape cycles to abrade through PJ at 40°C
A	>800
B	272

Wire Type	No. of scrape cycles to abrade through PJ at 5°C
A	>1350
B	212

[00036] Example of cold impact resistance improvement.

[00037] Method: wire size 6mm^2(conductor cross sectional area), impact weight 800g, drop height 275mm onto anvil, anvil area impacting on wire of dimensions 7mm x 2mm widening to 3.4mm via 45° taper each side, ambient temperature 5°C. Visual detection of insulation crack propagation.

Wire Type	Result of cold impact test
A	No cracks in PJ propagate away from site of anvil impact
B	Severe cracks in PJ, >5 mm in length, propagate away from site of anvil impact. PJ starts to peel off core

[00038] Example of solvent resistance improvement.

[00039] Method: wire size 0.75mm^2, length of wire 60mm,acetone immersion length 75% of wire length, immersion time 1hour, temperature 23°C

Wire Type	Result of acetone immersion test
A	No separation/delamination of core and PJ, no cracking of either insulation layer observed
B	PJ wrinkled very severely along immersed length, cracking spontaneously in two places, and exposing 2-3mm of core

[00001] BACKGROUND OF THE INVENTION

[00002] This invention relates to insulation for electrical wire or cable.

[00003] Wire and cable with dual wall insulation comprising a polyolefin inner layer and polyvinylidene fluoride (PVDF) outer layer have been commercially available for over 30 years. In such insulated products, the adhesion between the polyolefin and PVDF layers is negligible, and as a result the products suffer from the certain disadvantages.

[00004] SUMMARY OF THE INVENTION

[00005] It has now been discovered, according to the present invention, that ~~improved~~ insulation can be provided by a first layer consisting of ~~comprising~~ a first polymeric composition which comprises a ~~selected~~ carbonyl-containing polymer and which is as defined below, and an adjacent second layer consisting of ~~comprising~~ a second polymeric composition which comprises a ~~selected~~ fluoropolymer and which is as defined below, these layers being ~~. These layers can be~~ bonded together by cross-linking. The invention makes it possible to achieve high-performance bonding between such layers while retaining an acceptable balance in the complex relationships of other wire performance requirements. ~~To provide insulation having improved performance characteristics in one or more areas such as resistance to abrasion, peeling (especially if one of layers is damaged), blistering (especially if heat is applied), delamination, creasing and wrinkling (especially when the insulation is subject to mechanical stress or exposure to solvents).~~

[00006] In a first aspect, this invention-provides an insulated electrical wire comprising

1) a metallic conductor, and

2) insulation comprising

(i) a first layer which consists ~~is composed~~ of a first polymeric composition consisting of a first polymeric portion ~~component~~ and optionally a first additive portion ~~non-polymeric component~~, the first polymeric portion ~~component~~ comprising at least 60%, preferably at least 80%, by weight, based on the weight

of the first polymeric portion ~~component~~, ~~(or, in some embodiments, based on the weight of the whole composition)~~ of a carbonyl-containing polymer ~~(which~~ which has a non-aromatic backbone and which may be a homopolymer or copolymer, including terpolymer, ~~and which preferably has a non-aromatic backbone),~~ the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate, propyl acrylate or butyl acrylate), the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% , for example 15 to 28%, by weight of the carbonyl-containing polymer and any other repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene;

(II) a second layer which is in direct contact with the first layer at an interface, and which consists ~~is composed~~ of a second polymeric composition consisting of a second polymeric portion ~~component~~ and optionally a second additive portion ~~non-polymeric component~~, the second polymeric portion ~~component~~ comprising at least 50%, particularly ~~or~~ at least 90%, for example ~~substantially~~ 100%, by weight based on the weight of the second composition, of ~~at least one of~~ polyvinylidene fluoride (PVDF) or ~~and~~ a vinylidene chloride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene chloride, and

(b) repeating units derived from a partially or fully fluorinated co-monomer, preferably hexafluoropropylene (HFP);

the first layer being positioned between the conductor and the second layer.

[00007] In a second aspect, this invention provides an insulated electrical wire comprising

1) a metallic conductor, and

2) insulation which comprises

(i) a first layer which consists of a first polymeric composition consisting of a first polymeric portion and optionally a first additive portion, the first polymeric portion comprising at least 60%, preferably at least 80%, by weight, based on the weight of the first polymeric composition, of a carbonyl-containing polymer which has a non-aromatic backbone and which may be a homopolymer or copolymer, including terpolymer, the carbonyl-containing polymer comprising repeating units derived from a monomer which (a) can be copolymerized with an olefinic monomer and (b) contains a carboxylic acid ester group, preferably an acrylate or acetate, especially an alkyl acrylate (preferably methyl acrylate, ethyl acrylate, propyl acrylate or butyl acrylate), the units derived from said monomer constituting at least 5%, preferably at least 9%, more preferably at least 15% , for example 15 to 28%, by weight of the carbonyl-containing polymer, and any other repeating units of the carbonyl-containing polymer preferably being derived from an olefinic monomer, preferably ethylene, and

(ii) a second layer which is in direct contact with the first layer at an interface, and which consists of a second polymeric composition which consists of a second polymeric portion and optionally a second additive portion, the second polymeric portion comprising at least 50%, preferably at least 90%, for example 100%, by weight, based on the weight of the second polymeric composition, of polyvinylidene fluoride (PVDF) or a vinylidene fluoride (VDF) copolymer consisting essentially of

(a) repeating units derived from vinylidene fluoride, and

(b) repeating units derived from a partially or fully fluorinated comonomer, preferably hexafluoropropylene (HFP);

the first layer being positioned between the conductor and the second layer.

[00008] Preferably, in each of the first and second aspects of the invention, ~~Preferably,~~ the layers (i) and (ii), while in contact with each other, have been subjected to conditions which cause cross-linking of polymers at the interface between them, preferably by subjecting the layers to

radiation, particularly ionising radiation. The cross-linking is preferably such that at least one of the following conditions is fulfilled

(a) the peel bond strength between the layers, measured by ASTM 81876- 95, is ~~to~~ at least 5N, preferably more than 10N,

(b) when a sample of the insulated electrical wire 60 mm long is immersed to a depth of 42 mm in a bath of acetone ~~4.2 mm deep~~ at 23 °C for 1 hour, there is no delamination of the two layers, and

(c) the peel bond strength between the layers after the crosslinking, measured by ASTM B1876-95, is at least 50%, preferably at least 100%, especially at least 500% or 1000%, greater than the peel bond strength between the layers before the crosslinking, measured by ASTM B1876-95.

~~Throughout this specification, including the claims, the terms "a", "an" and "the" before an item mean that there can be a single such item or two or more such items, unless the context makes this impossible (for example, in the first aspect of the invention, the first polymeric component can comprise a single carbonyl-containing polymer as defined or two or more such polymers; and the second polymeric component can contain a single fluoropolymer or a mixture of two or more fluoropolymers); and the term "consisting essentially of" certain ingredients means that those ingredients are necessarily present and that other ingredients may be present providing that their presence does not substantially change the properties of the insulation.~~

[00009] A third ~~second~~ aspect of the invention provides a method of making an insulated wire or cable, the method comprising the steps of

(A) providing an electrical conductor surrounded by

(i) a first layer which consists ~~is composed~~ of a first polymeric composition as defined in the first or second aspect of the invention; and

(ii) a second layer which consists ~~is composed~~ of a second polymeric composition as defined in the first or second aspect of the invention;

the first and second layers being in direct contact with each other at an interface, and the first layer being positioned between the conductor and the second layer ~~one~~; and

(B) exposing the layers while in contact with each other to ionising radiation which causes cross-linking of polymers at the interface.

[00010] DETAILED DESCRIPTION OF THE INVENTION

[00011] In some embodiments of the invention, the first polymeric portion ~~component~~ contains, in addition to ~~When the first polymeric component does not consist solely of~~ the carbonyl-containing polymer, polyethylene, preferably ~~any other polymer present in the first polymeric component is preferably a polyolefin, particularly~~ high-density polyethylene.

[00012] Each of the layers (i) and (ii) optionally contains, in addition to the polymeric portion ~~component~~ of the composition, an additive portion to give the composition required properties. ~~a non-polymeric component comprising additives such as anti-oxidants, pigments, fillers, flame retardants, etc, to enhance mechanical, thermal, electrical etc. properties of the insulation.~~

[00013] Examples of additives which may be present in the first polymeric composition are cross-linking promoters, antioxidants, pigments, fillers, flame retardants, etc. as known per se. Examples of additives which may be present in the second polymeric composition are cross-linking promoters, pigments, plasticizers, stabilizers, antioxidants and process aids.

[00014] A convenient method for gauging the bond strength between the layers (i) and (ii), when they have been fabricated onto a wire, is to immerse ~~place~~ a sample wire, of total length 60mm, ~~into~~ in a bath of acetone (e.g. Fisher Scientific UK, AR certified grade acetone) at 23°C for 1 hour, to a depth of 42 mm. ~~acetone equivalent to 70% of the length of sample wire, at 23 (+/- 3)°C, for a period of 1 hour.~~ Wires with negligible bonding of the insulation layers experience an extension of the outer layer, along the axis of the wire, that is independent of any

extension of the inner layer, and/or wrinkling of the outer layer such that it delaminates from the inner layer in places. When it occurs, the above-mentioned extension of the outer layer typically results in a "tube" extending for 1mm or more beyond the cut end of the inner layer. Wires with significantly bonded insulation layers experience an extension of both layers without separation, beyond the cut edge of the conductor, along the axis of the wire and/or wrinkling of the two layers together, without delamination. Any such wrinkling of the two layers together can be distinguished from wrinkling only of the outer layer by examining a cross-section of the wrinkles under a microscope.

[00015] In the method of the invention, step (A) can make use of any process which causes intimate contact between the layers (i) and (ii). Examples include coating the second polymeric composition onto a pre-formed layer of the first polymeric composition, and dual or multi-walled extrusion to form insulation layers respectively containing one or other of the polymeric compositions. The layers made from the two different compositions can be coextruded, tandem extruded, multipass extruded, or coated by other means. Known wire insulation processes such as tube draw-down extrusion may be used to form one or more of the layers, but pressure extrusion as known per se is preferred for optimum adhesion of the second and any subsequent insulation layers to be applied to a pre-formed underlying layer. The first layer can optionally be ~~In some embodiments of the invention, the first layer is~~ in direct contact with the conductor. The insulation can consist of a first layer as defined and a second layer as defined. The insulation can be, for example, multiple alternating layers of the first and second polymeric compositions. ~~In some embodiments of the invention, the defined first and second layers are the sole insulation around the conductor. In other embodiments, the first and second layers are part of multilayer insulation including one or more other layers.~~

[00016] In step (B) of the method of the invention, the insulation on the wire is exposed to conditions which cause a cross-linking reaction. The cross-linking may involve chemical reagents such as peroxides, but preferably is effected by radiation, especially radiation from a source of ionising radiation capable of causing the formation of free radicals and, thus, cross-links, in the polymers, some of which should preferably be formed in the region of the interface between the two compositions. Penetration of the radiation into the insulation at least as far as

the interface is therefore desirable, although not necessarily essential if ion or radical mobility, for example, enables molecular reactions to continue at or near the interface after the radiation process. The radiation source could, for example, be a radio-isotope, or an X-ray source, or possibly a non-ionising radical-generating source, for example a UV source, but is preferably an electron beam, more preferably one providing a beam dose greater than 2 Mrads, preferably at least 5 Mrads, more preferably at least 10 Mrads, very preferably at least 15Mrads, into the material.

[00017] It has been found that, when the cross-linking is effected by ionizing radiation, enhancements to the interfacial bond strength may be obtained by including a cross-linking promoter ("pro-rad") in the first and/or second polymeric composition. Known pro-rads may be used, preferably methacrylate/acrylate based pro-rads, e.g. imethylolpropanetrimethacrylate (TMPTM).

[00018] Experimental results:

[00019] All results quoted in the tables below were obtained by testing pressed plaques of the two materials prepared by the usual polymer handling techniques, well known per se. The plaques were pressed together to bond them face-to-face and the bonded assembly was irradiated as indicated. Plaques were used for these demonstration experiments rather than wires, due to the relative ease of measuring bond strength on plaques. Conditions for these experiments were as follows:

Plaque dimensions: 150mm by 150mm by 0.85mm

Pressing temperature: 200°C

Pressing time: 2 minute preheat, 1 minute at pressure

Pressing pressure: 20-40 Tons over a 300mm by 300mm metal plate

Cooling conditions: 2 minutes between water cooled, 300mm by 300mm, metal plates, at a pressure as above.

[00020] In the Experimental Results shown below, the first composition (comprising the carbonyl-containing polymer) is referred to as the polyolefin-based material and as Material 1, and the second composition is referred to as the PVDF-based material and as Material 2; and the following abbreviations are used (in addition to those already given). EVA is ethylene/vinyl acetate copolymer. VA is vinyl acetate. EEA is ethylene/ethyl acrylate copolymer. EA is ethyl acrylate. EMA is ethylene/methyl acrylate copolymer. MA is methyl acrylate. HDPE is high-density polyethylene. PVDF is polyvinylidene fluoride.

[00021] Example of Effect of Radiation Dose on Bond strength developed between appropriate polyolefin and PVDF-based materials

Material 1	Material 2	Dose(Mrad)	Peel force (N)
EVA copolymer of 25wt% VA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	0	0.5
Same as above	Same as above	15	40
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	0	1
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	8	24
EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content	20	52
Ethylene/acrylic ester/maleic anhydride terpolymer of 19wt% acrylic ester content	VDF/HFP copolymer of 10wt% HFP content	0	<5
Ethylene/acrylic ester/maleic anhydride terpolymer of 19wt% acrylic ester content	VDF/HFP copolymer of 10wt% HFP content	20	21

[00022] Example of Effect of Percentage Comonomer in Ethylene Copolymer Material on bond strength to appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
EMA copolymer with 9wt% MA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	4
EMA copolymer with 28wt% MA content	Same as above	20	45

[00023] Example of Effect of percentage Copolymer in a polyolefin polymer blend on bond strength with appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel force (N)
100% HDPE	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	0
20% HDPE + 80% EEA copolymer of 15wt% EA content	Same as above	20	70

[00024] Example of Effect of PVDF-based material type on bond strength with appropriate polyolefin based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
EVA copolymer with 25wt% VA content	PVDF homopolymer	15	4
As above	VDF/HFP copolymer of 10wt% HFP content	15	17.5

[00025] Example of Effect of the addition of Pro-rad in Olefinic Material on bond strength with appropriate PVDF-based material after electron beam crosslinking

Material 1	Material 2	Dose(Mrad)	Peel (N)
20% HDPE + 80% EEA copolymer of 15wt% EA content	VDF/HFP copolymer of 10wt% HFP content +7.5wt% additives	20	70
19% HDPE + 77%EEA copolymer of 15wt% EA content + 4% TMPTM pro-rad	Same as above	20	>130

[00026] Examples of Wire Construction

[00027] An electrical wire in which the insulation consists of two polymeric layers bonded together according to the present invention was made as follows:

[00028] The inner layer of insulation (i.e. nearer to the wire conductor) was a polyolefin-based material, consisting predominantly of (a) an EEA copolymer containing 15wt% EA and (b) HDPE in a weight ratio of approximately 8:2 copolymer:HDPE, with usual other additives present in smaller proportions including crosslinking promoters, stabilisers, antioxidants, pigments and process aids at a total level of 24wt%. This layer was pressure extruded onto the metallic conductor.

[00029] The outer layer of insulation consisted predominantly of a PVDF/HFP copolymer containing 10wt% HFP, which in this example contains a crosslinking promoter, and other known additives such as pigments, plasticisers, stabilisers, antioxidants and process aids in usual proportions totalling 7.5wt%. This outer layer was pressure extruded in a separate operation onto the pre-formed inner layer. This coated wire product was then passed through an electron beam, and received a radiation dose of 20Mrads.

[00030] In a second example a wire was made as above, in which the crosslinking promoter in the inner layer was 4% TMPTM, and the the outer layer of insulation was comprised solely of the PVDF/HFP copolymer containing 10wt% HFP. This coated wire product was then passed through an electron beam, and received a radiation dose of 20 Mrads. This wire was subjected to the acetone immersion test, confirming that the insulation layers were significantly bonded together.

[00031] In a third example, a wire of the same construction as the second example was made by tandem pressure extrusion of the inner and outer insulation layers. This coated wire product was then passed through an electron beam, and received a radiation dose of 20 Mrads.

This wire was subjected to the acetone immersion test, confirming that the insulation layers were significantly bonded together.

[00032] Demonstration of Improved performance of wires constructed as in the second example above, relative to current commercially available wire.

[00033] A wire of the above construction and manufacturing process (designated wire A) was compared with a market leading commercially available polyolefin/PVDF dual-walled wire (designated wire B) of the same dimensions, over a range of tests for wire robustness relevant to harsh handling and end-use environments. The following results were obtained.

[00034] Example of scrape abrasion resistance improvement.

[00035] Method: Equipment=conventional type wire scrape abrader, wire size 0.75mm^2(conductor cross sectional area), blade type flat, width 3.5mm held perpendicular to wire, with 0.05mm radiused edges each side, applied load 1.8kg, stroke length 10cm, at 55 cycles/minute

Wire Type	No. of scrape cycles to abrade through PJ at 40°C
A	>800
B	272

Wire Type	No. of scrape cycles to abrade through PJ at 5°C
A	>1350
B	212

[00036] Example of cold impact resistance improvement.

[00037] Method: wire size 6mm^2(conductor cross sectional area), impact weight 800g, drop height 275mm onto anvil, anvil area impacting on wire of dimensions 7mm x 2mm

widening to 3.4mm via 45° taper each side, ambient temperature 5°C. Visual detection of insulation crack propagation.

Wire Type	Result of cold impact test
A	No cracks in PJ propagate away from site of anvil impact
B	Severe cracks in PJ, >5 mm in length, propagate away from site of anvil impact. PJ starts to peel off core

[00038] Example of solvent resistance improvement.

[00039] Method: wire size 0.75mm^2, length of wire 60mm,acetone immersion length 75% of wire length, immersion time 1hour, temperature 23°C

Wire Type	Result of acetone immersion test
A	No separation/delamination of core and PJ, no cracking of either insulation layer observed
B	PJ wrinkled very severely along immersed length, cracking spontaneously in two places, and exposing 2-3mm of core